

# **The Application of the Empirical Mode Decomposition and Hilbert Spectral Analysis to Field Data and Future Experimental Designs**

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## **LONG-TERM GOAL**

My long term goal is to contribute to our understanding of the dynamics of physical ocean phenomena through detailed examination of the field data. Of particular interest to us is to learn from the field data analysis so that we can design future field experiments more effectively based on the past data.

## **OBJECTIVES**

Field data are all nonstationary, and ocean phenomena are most generated by nonlinear processes. To understanding this, we cannot use methods developed based on the linear and stationary assumptions. Our objectives here are to extract the characteristic time scales from field data to define the dynamics of the phenomena, so that we can separate the tidal components from the coastal field current data; study the coupling of the wind and current fields; calculate the statistics of the data for validation of model results; explore the utilization of the method to other coastal applications; and develop the method as a tool for design future field experiments.

## **APPROACH**

The tasks of this study are primarily on the data analysis methodology development. Once the methodology is developed, we will use the method to extract the characteristic time scales from field data to define the dynamics of the phenomena. In this step, we will separate the tidal scale from the non-stationary meteorological cycles. In this se-tided data set, we will study the coupling of the wind and current fields to establish the generation and relaxation of the wind induced current field. Then we will calculate the statistics of the data for validation of model results, and to explore the utilization of the method to other coastal applications. Finally, we will use the sum of this knowledge to define a methodology for future field experimental design based on limited data sets.

## **WORK COMPLETED**

Together with Dr. Ronald Lai of MMS, we have extract field data from the Gulf Satations on current vectors and wind. We have also developed methods to extract time scale of tides, wind epsoides, and longer term drifts. Additionally, we have developed the methods to extract the direction and the phase of the current vectors to make comparisons on the depth dependent wind responses.

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## RESULTS

For the first year, we have been concentrated on methodology development. Before the field data were made available to us, we have finished in developed a data analysis package for Hilbert spectral analysis. This package is under further evaluation. About sixty universities, government laboratories, and private companies are teating the package with us.

Meanwhile, we have also test the data analysis methodology on various data sets that including the whether phenomena, ploar ice coverages, earthquakes, and bio-engineering. In every case, we found new insights into the mechanism through the detailed time-frequency-energy presentation of the data. Results are published in several papers by me and my colleagues. I feel confident that the methodology is ready for coastal oceanography applications.

## IMPACT/APPLICATION

The methodology developed for this study is also applicable to a wide range of other problems. The original method was patented by NASA. And the method was awarded the NASA Space Act Award in the *exceptional* category. The NASA Headquarters Inventions and Contributions Board cited that this new method of data analysis has turned out to be "one of the most important discoveries in the field of applied Mathematics in NASA history." This new method is expected to provide a more accurate result for analyzing nonlinear and nonstationary data than the classical Fourier method of spectral analysis. The application is to be far beyond the oceanography applications.

## TRANSITIONS

The method has been patented by NASA in four different patents. The first one has just been granted. A licsense is been neigotiated with a private to market the Hilbert Spectral analysis package.

## RELATED PROJECTS

1. Submarine wake study. Supported by NSWCCD Carderock Division, I have just finished a project on analysis the model submarine wake for the next generation submarine design.
2. Golbal wind field study. Supported by NASA Jet Propulsion Laboratory, I am study the satellite sensed wind field over the World's oceans. This work is still on going. The goal is to extract the prominent wind field scales for gobal wind field statistical study.
3. Speech and sound study. Working with colleagues here and NIST, I am working on analysis of sound and speech. This again is a problem of scale extraction.

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None

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